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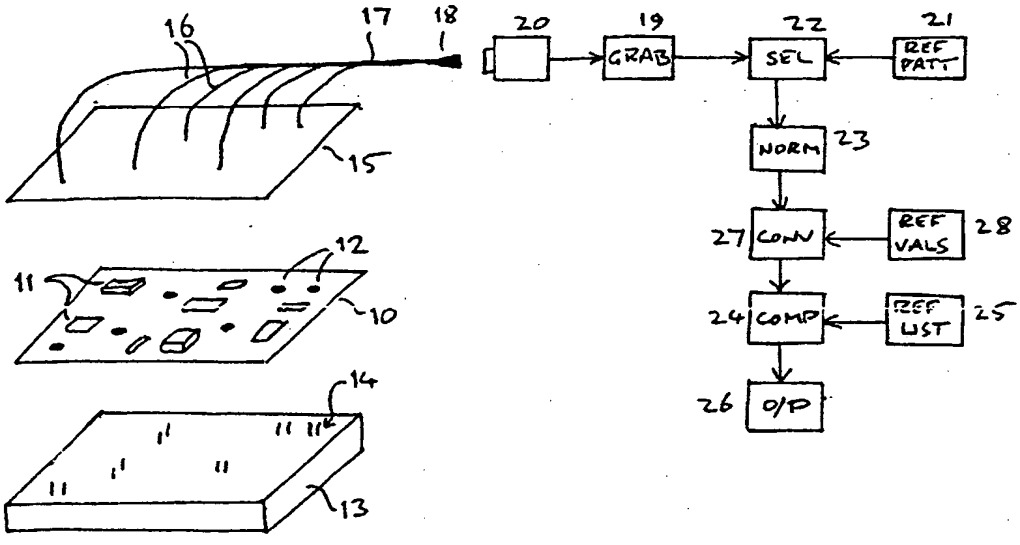
(54) Abstract Title
Circuit board component testing

(57) Apparatus for testing printed circuit boards having a plurality of LEDs thereon. A "bed of nails" unit 13 energises the individual LEDs 12. An optical coupling unit comprises a plurality of optical fibres 16 each having one end located adjacent to a respective LED and the other end located adjacent to the colour television camera 20. The optical fibres are arranged in a regular pattern at the camera 20. Signal analysis circuitry 22-26 determines the colour of the light transmitted to the camera via each of the optical fibres. The signal analysis circuitry averages the signals from each of a plurality of regions corresponding to the camera ends of the optical fibres, converts each of the averaged signals to a standard colour code, and matches each of the colour codes against a list of reference codes.



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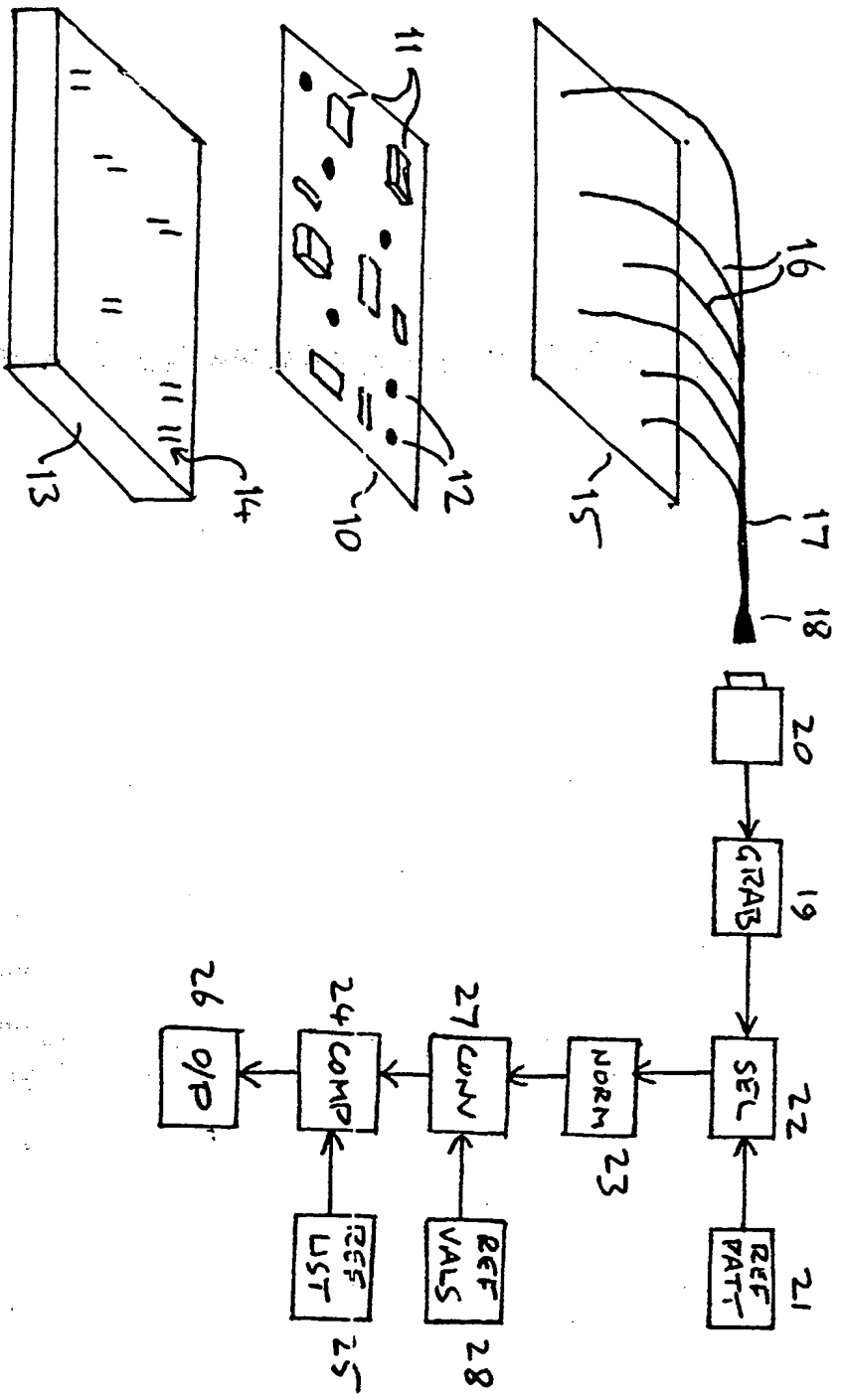

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Circuit Board Testing

The present invention relates to the optical testing of printed circuit boards.

To produce a completed printed circuit board, the board itself is first manufactured, with holes being formed in it and tracks deposited on it. The necessary components are then assembled on it, generally automatically. The components are carried on reels, one reel for each type of component, and the assembly machine transfers the components from the reels to the appropriate places on the board. The board is then passed through a soldering machine to solder the components to the board.

Once the board has been manufactured, it is then generally desirable or necessary to test it. There are two basic techniques for testing printed circuit boards. The board may be checked optically for the presence of the correct components, and electrically for correct operation.

The main purpose of optical testing is to check that the correct components are in the correct positions on the board; that is, to detect errors resulting from a wrong reel being placed on the assembly machine and malfunction of that machine. Optical checking and testing generally involves scanning the board (automatically), or selected areas of it, and comparing the resulting image with a reference image obtained from a board which is known to be sound. The reference image may be obtained from a physical reference board but is more usually a stored image.

The main purpose of electrical testing is to check that the soldering has been successful; that is, to detect when component pins have failed to pass through their holes on the board and failures to solder component pins to the tracks on the board. Electrical

testing may be performed by exercising the board by applying a sequence of test signals to it via its connector(s), or by applying test signals to various selected regions or components on the board by means of a "bed of nails" tester (or, in principle, by a combination of the two). Of course, this testing, like optical testing, can also detect certain other faults as well.

One type of circuit board which is becoming increasingly popular in certain situations includes a number of light emitting diodes (LEDs). A major application of such boards is in instrument panels, such as in cars. The presence of the diodes on these boards can be checked by optical testing, just as for other types of components on the boards; and the operation of these diodes can be checked by electrical testing, just as for other types of components, by determining whether they are open-circuited.

We have realized, however, that testing LEDs presents some unusual difficulties, and the main object of the invention is to provide an improved method of testing circuit boards with LEDs on them.

A particular problem arises when the LEDs are of more than one colour, because the colour of an LED (ie the colour which it produces when energized) is not generally correlated with its physical appearance. Further, the manufacturers of LEDs often make no particular effort to enable LEDs of different colours to be readily distinguished; LEDs are typically manufactured with a white or whitish shroud or housing regardless of their colour. It is therefore relatively easy for a reel of the wrong colour LEDs to be placed on the circuit board assembly machine.

According to its main aspect, the invention provides testing apparatus for testing printed circuit boards having a plurality of LEDs thereon, the tester comprising:
a "bed of nails" unit for energizing the individual LEDs;
colour television-type camera means;

an optical coupling unit comprising a plurality of optical fibres each having one end located adjacent to a respective LED and the other end located adjacent to the camera means; and signal analysis circuitry for determining the colour of the light transmitted to the camera means via each of the optical fibres.

Preferably the optical fibres are arranged in a regular pattern at the camera means.

The signal analysis circuitry can conveniently comprise means for averaging the signals from each of a plurality of regions corresponding to the camera ends of the optical fibres, means for converting each of the averaged signals to a standard colour code, and means for matching each of the colour codes against a list of reference codes.

A tester embodying the invention will now be described, by way of example, with reference to the drawing, which shows the tester in diagrammatic form.

Referring to the drawing, the tester is intended for testing a printed circuit board (PCB) 10 which carries a variety of components 11. These components include several LEDs 12, which are of several different colours, eg red, amber, green, and blue.

As mentioned above, the main application of such boards is in instrument panels for eg cars. The different colours are used for different types of indication; thus red is normally used for warning lights, while other colours are used for other indications (eg the full beam headlight indication is normally blue, and direction indicator lights are normally green). The layout of the indications on an instrument panel is normally dependent on a variety of factors; related indications are normally grouped together, the indications may be arranged around or combined with dials, and so on. The LEDs are therefore in general located irregularly on the board 10, with the individual LEDs being relatively small compared to the size of the board.

The board 10 is placed on a bed of nails unit 13 which has a plurality of spring-loaded pins 14 which are located in positions corresponding to the LEDs 12. The pins can conveniently be in pairs, one pair for each LED. By energizing the pins, the LEDs can be energized. Colour television-type camera means 20, which may conveniently be a charge-coupled device, is arranged to scan the board and thereby the LEDs on it.

As noted above, the LEDs are relatively small, and are in general arranged more or less randomly over the board. A camera with a typical resolution, eg 512 x 512 pixels, will therefore be unable to form images of the individual LEDs with acceptable resolution. An optical coupling unit 15 is therefore placed above the board 10, comprising a plurality of optical fibres 16. Each fibre has one end located in the coupling unit above a respective one of the LEDs 12; the other ends of the fibres 16 are gathered together in a fibre cable 17 which ends in a termination 18 in which the fibres are arranged in a regular pattern, which can conveniently be a hexagonal array. The camera 20 is arranged facing the cable termination 18, and scans the ends of the fibres 16 in the termination 18.

The camera 20 feeds an image grabber unit 19, which enables an image of the entire set of LEDs to be obtained from a single scan. The processing of the stored image can be carried out relatively rapidly, compared to the time which would be taken if the camera scanned the board separately for each LED.

The image grabber unit 19 feeds a selector unit 21, which is also fed from a reference pattern unit 22. Unit 22 defines the pattern of fibre ends in the termination 18, eg as a set of circles which match or are slightly smaller than the ends of the fibres. Each time the television camera scan passes across one of the areas defined by the pattern unit 22, the output is accumulated in a corresponding register. At the end of a scan, therefore, the selector unit contains a set of accumulated values, one for each of the LEDs.

Each set of values is a triplet of values, representing the three colour outputs of the camera. These values are passed to a normalizing unit 23, which normalizes them to a standard or normalized form, in which the colour values are expressed as ratios. This is because the brightnesses of the various LEDs can vary substantially, as a result of different drive voltages and, more importantly, the LED manufacturing process, which tends to leave a powder coating of varying density on the LEDs; this powder coating will affect the brightness of the LEDs without significantly affecting their colours.

The normalized sets of values are then passed to a conversion unit 27, which converts each set of values to a colour signal, ie Red, Amber, Green, Blue, or Invalid. The first four signals are generated if the set of values matches the reference values for that colour closely enough; the Invalid signal is generated if an acceptable match cannot be achieved with any of the four sets of reference values. The conversion unit may contain four sets of reference values, one for each colour. It is preferred, however, to control the conversion unit from a reference values unit 28 which contains a plurality of different sets of reference values and a table indicating which set of values is to be used for each different LED. The system can therefore recognize different types of LED with the same nominal colour in different positions on the board 10.

The colour signals are then passed to a comparator 24, which is also coupled to a reference list unit 25. Unit 25 contains a list of the LEDs 12 with the colour of each, and unit 24 compares these colours with the colour signals. The results of the comparison are fed to an output unit 27. If all comparisons are successful, the board has passed the test; if any comparison fails, the board has failed the test.

The image processing of blocks 21-26 may conveniently be performed by a suitably programmed computer.

The present technique can readily be extended to testing boards for other components according to colour, eg for checking resistors for their colour coding to confirm that they have the correct resistance values.

Claims

1 Testing apparatus for testing printed circuit boards having a plurality of LEDs thereon, the tester comprising:
a "bed of nails" unit for energizing the individual LEDs;
colour television-type camera means;
an optical coupling unit comprising a plurality of optical fibres each having one end located adjacent to a respective LED and the other end located adjacent to the camera means; and
signal analysis circuitry for determining the colour of the light transmitted to the camera means via each of the optical fibres.

2 Testing apparatus according to claim 1 wherein the optical fibres are arranged in a regular pattern at the camera means.

3 Testing apparatus according to either previous claim wherein the signal analysis circuitry comprises means for averaging the signals from each of a plurality of regions corresponding to the camera ends of the optical fibres, means for converting each of the averaged signals to a standard colour code, and means for matching each of the colour codes against a list of reference codes.

4 Testing apparatus substantially as herein described and illustrated.

5 Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

INVESTOR IN PEOPLE

Application No: GB 0102435.5 **Examiner:** Jane Croucher
Claims searched: 1 to 4 **Date of search:** 18 October 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): G1A (AAJP, AMT)

Int Cl (Ed.7): G01R (31/28)

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	None	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.